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An Experimental Study of the Effects of Subliminal Stimuli

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TABLE OF CONTENTS

	PAGE
INTRODUCTION	1
STATEMENT OF THE PROBLEM	4
HISTORICAL BACKGROUND I	5
HISTORICAL BACKGROUND II	6
1. "Telepathic" phenomena	7
2. Experiments indicating hyperaesthesia	9
3. Phenomena of the "subconscious"	10
4. Data from psychophysical experiments	11
5. Laboratory experiments directly concerned with the influence of the subliminal stimulus	12
PRELIMINARY SURVEY OF THE EXPERIMENTS	22
APPARATUS	23
EXPERIMENT I	26
EXPERIMENT II	32
EXPERIMENT III	37
STATISTICAL METHODS	48
SUMMARY	54
CONCLUSIONS	55
REFERENCES	56

TABLES AND FIGURES

			PAGE
Table	I.	Total number of subjects and exposures	23
Table	II.	Comparison of certainty ratings, Experiment I	30
Table	III.	Comparison of critical ratios, Experiment I	31
Table	IV.	The frequencies of stimuli and percentage of correct responses, Experiment II	34
Table	V.	The extent of extra-chance influences from the form patterns, Experiment II	35
Table	VI.	Comparison of critical ratios for experiments by Coover and by Collier	35
Table	VII.	Comparison of data for "guessing" form before and after identifying circle opening, Experiment II	36
Table	VIII.	Summary of the results of the four variations, Experiment III	41
Table	IX.	Percentage of correct choices in the four variations, Experiment III	41

Figure 1.	External side view of the tachistoscope with the exposure card partly withdrawn	24
Figure 2.	Top view showing internal construction of tachistoscope	24
Figure 3.	Frequency of responses associated with each of the subliminal stimuli in Variation I, Experiment III	51

AN EXPERIMENTAL STUDY OF THE EFFECTS OF SUBLIMINAL STIMULI *

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Introduction

The part played by subliminal stimuli in psychological processes has been experimentally investigated in a relatively few instances. While it has not been overlooked in psychological theory that these stimuli modify responses, the concept has not been adequately exploited. The dependence, for example, of perceptual structurizations upon subliminal stimuli is a relationship which is almost entirely unexplored. Investigators are more and more recognizing the possible influences of subliminal stimuli in the experimental situation. It is probably frequently true that both subject and experimenter are misled by their effects and the resulting data are not properly interpreted. Adequate control in the experimental situation implies modification of technique which either isolates the effects of subliminal stimuli or corrects for them. Insofar as subliminal stimuli produce effects upon behavior, they become, themselves, objects for psychological investigation. Complete descriptions of behavior cannot be made without taking into account the effects of stimuli not only of magnitudes sufficient to excite awareness responses, produce verbal reports, or condition behavior, but also of stimuli the

* This monograph is a revision and extension of part of the writer's Ph.D. dissertation which was submitted to the graduate school of Northwestern University in June, 1934. The experimental work was done in part in the psychology department of Northwestern University and in part in the psychology department of Johns Hopkins University. The entire experimental project was planned under the sponsorship of Franklin Fearing, now at the University of California at Los Angeles. The writer is also indebted to Knight Dunlap for advice concerning both apparatus and method and to the late John Edgar Coover for his aid in the general statistical analyses. Professor Coover also contributed a special method used in correcting for what he called "mental habit."

intensities of which are sub-threshold in magnitude, yet effective in modifying behavior.

These relatively uninvestigated effects of subliminal stimuli may be related to at least the following five typical aspects of the field of psychology: (1) attention, (2) the psychometric function, (3) perception, (4) social behavior, and (5) aesthetic experiences. These labels, of course, do not indicate mutually exclusive functions, but are convenient designations for lines of attack upon the problems of behavior.

(1) Attending may be described, in part, as the facilitation of some processes with the concomitant inhibition of others. The facilitated responses of the individual are those which combine to increase reception of the stimulus, while responses to distracting stimuli are inhibited. This coincident depression or inhibition of "marginal" stimulation is not necessarily total or complete. Insofar as these partially depressed processes are operating, they become a part of the conditions of behavior. Experiments upon attention seem to have attacked almost exclusively the dominant set of responses and have neglected the background of subordinated responses. Technical difficulties involved in the isolation of effects from these partially suppressed processes account in part for the neglect.

(2) One expression of the psychometric function is based upon the relative frequency with which the subject discriminates differences between standard and variable stimuli when those differences are varied in a systematic order. These judgments are subject to a great variety of psychophysiological conditions. The observer is frequently quite unaware of the influences leading to judgments associated with or opposed to a real difference between the stimuli. To the extent that the correct judgments of the subject exceed the chance limit, without his being aware of a real difference, the subliminal difference has operated as an extra-chance influence. Whatever differential responses the individual is capable of, such as judgments, choices, and guesses, are probably constantly biased by a mass of influences which never rise into clear consciousness.

(3) The perceptual field may be described as a structured relationship wherein stability varies with such factors as biological equipment, experience, and mental set. The figure-ground relationship, one of the basic structurizations of perceiving, is probably alterable in many ways by the subtle influences of unnoticed stimuli. The extent to which subliminal or unnoticed stimuli influence the stability of perceptual patterns would reveal the significance of such stimuli and perhaps also of some of the more subtle conditions modifying the way in which the pattern becomes organized for the perceiving individual.

(4) Unnoticed stimuli undoubtedly play an important rôle in social behavior. Slight changes in facial expression and minute alterations in forms of bodily posture * are known to be sufficient to influence responses of neighboring observers. Individuals may influence one another without either of them being aware of the mutual modifications. Conditioning to these unnoticed changes probably begins early in the development of the individual. It is conceivable that many individuals may become increasingly more responsive to slight signs and cues from others that have social significance. Little, as yet, has been done to determine the type and significance of these unnoticed social influences. To know the conditions under which these stimuli become effective might add much to our systematic knowledge of human behavior.

(5) As an example of the complex relationship of unnoticed stimuli to the aesthetic attitude, the empathic response may be cited. In this case the attitude arises from a mass of unnoticed influences of proprioceptive origin. Feeling accompanying the perception of weight, strain, balance, symmetry, striving, activity, and passivity arise from incipient proprioceptive responses as the individual contemplates the object. This behavior-set, incompleted in overt responses, gives important meaning values to conscious experience. In spite of the fact that the impression is unitary, the individual is usually unaware of the mass of stimuli subserving the experience.

* See reference to Elberfeld horses (**57**) ; also page 8.

Statement of the Problem

The object of this investigation was to study the concurrent effects of stimulating simultaneously two sense organs with objectively similar subliminal stimuli. Dunlap (**21**) and Bresslar (**10**) have shown with the Mueller-Lyer illusion that imperceptible shadows influence slightly, though consistently, the judgment of line lengths. Boris Sidis (**63**) discovered that, when no degree of confidence accompanied guesses regarding small digits and letters shown at a distance, the frequency of right guesses was still significantly in excess of chance. Washburn's researches (**71**) not only confirmed the work of Sidis, but also indicated that whispering the letters and digits was an influence toward right guesses even though the subject insisted that nothing was heard. Coover's experiments (**16**), more definitely controlled by instructions to the subject and by tachistoscopic exposures of stimuli, revealed that subliminal impression operated as a definite extra-chance influence. But all these experiments, as well as others referred to later, were concerned only with the effects of a subliminal stimulus presented to one sense modality.

Data from numerous experiments indicate that processes simultaneously aroused frequently produce either reinforced or inhibited responses. Organic unity evidently depends upon the accentuation of some processes and the concomitant subordination of others. Literature summarized by Fearing (**23**, **24**, **25**) and by Misbach (**52**, **53**) indicates that reciprocal relations exist between reflexes, and between a reflex and a voluntary response when they are simultaneously aroused. Dunlap and Wells (**22**) found that the reaction time of human subjects was decreased when an auxiliary stimulus was introduced. Hartmann (**34**, **35**) discovered that visual acuity was consistently increased when auxiliary stimuli were simultaneously presented.

More specifically, therefore, the purpose of the present investigation was to study intermodality relationships when geometric forms, subliminal in size, were presented simultaneously to the peripheral visual field and to the skin of the forearm. The objectively similar patterns were the following: circle, hexagon, square, diamond, triangle, and cross.

Historical Background

I

Leibnitz (**48, 49**) seems to have been among the first to point out possible effects from subliminal stimuli. It is apparent that from his studies of calculus he developed the notion that minute gradation from the infinitely small to the infinitely large was basic to all existence. This necessary continuity required that nothing spring into being suddenly, but that all results have their train of causes into the infinitely minute. He wrote,

"Nothing takes place all at once, and it is one of my great maxims, and one among the most completely verified of maxims, that nature never takes leaps; which I called the *law of continuity* . . . ; and the use of this law in physics is very considerable; it is to the effect that we always pass from small to great, and vice versa, through that which is intermediate in degrees as in parts; and that a motion never immediately arises from rest nor is immediately reduced to rest, but comes or goes through a smaller motion. . . . And all this leads us to think that noticeable perceptions also come by degrees from those which are too small to be noticed. To think otherwise is to know little of the illimitable fineness of things, which always and everywhere contains an actual infinity" (**49**, p. 377).

He said also that

". . . there are countless indications that there is at every moment an infinity of perceptions within us, but without apperception and without reflexion; that is to say, changes in the soul itself of which we are not conscious (s'apercevoir), because the impressions are either too small or too numerous, so that each is not distinctive by itself, but nevertheless in combinations with others each has its effect and makes itself felt, at least confusedly, in the whole" (**49**, p. 370f).

These minute changes of which the individual is not conscious were called *petites perceptiones.* Leibnitz illustrated the theory of the *petites perceptiones* by referring to the sounds made by waves of the sea upon the shore. The so-called moaning, heard at a distance, is made up of many minute sounds individually inaudible in the confused combinations. But he said that we must be affected a little by the motion of each wave, however small it may be, otherwise we would not perceive the total, for "a hundred thousand nothings cannot make something" (**49**, p. 370).

"After this I should add little, if I were to say that it is these *petites perceptiones* which determine us on many occasions without our thinking it, and which deceive people by the appearance of an indifference of equilibrium, as if for

instance we were completely indifferent whether to turn to right or to the left" (**49**, p. 370f).

Leibnitz's theory of the *petites perceptiones* is important in the history of psychology in that (1) it presents one of the first suggestions of a threshold concept; (2) it is, in part, the basis for later theories of a "subconscious mind" and its effect upon consciousness and behavior; and (3) the theory that the subliminal stimulus is effective is definitely implied.

Sir William Hamilton (**33**) used the concept of the *Minimum Visibile* * to illustrate his agreement with Leibnitz. He said that if a *Minimum Visibile* were divided into two parts neither would be a definite object of vision. In spite of this, each half must produce its effect or there could be no effect when the two halves were brought together. Other illustrations used are similar to those of Leibnitz. The distant forest may not be separable in perception as distinct leaves and trees but, even so, each part must necessarily produce its share of the total effect.

Wundt's discussion of threshold and sub-threshold sensations is of interest here. He said,

"And a sensation may exist long before it can be sensed. We only sense it when it reaches a definite intensity. But though in this statement we recognize the equivocation, we have not done away with it. The equivocation is explained by the fact that when the word first appeared in language the naïve consciousness which produced it knew only those sensations and sensation-differences which it was itself able to recognize as such. Not till scientific reflection had arisen was the human mind forced to the conclusion that there must be sensations and sensation-differences which it was inadequate to recognize for the reason that sensations neither arise nor alter abruptly, but only through continuous gradations" (**72**, p. 44).

In the same treatise from which the above quotation is derived, Wundt distinguished between positive and negative sensations. The negative sensations are evidently afferent processes of insufficient intensity to produce a conscious response, while positive sensations are of supra-threshold intensities. In the concept of the "continuous gradation", the influence of Leibnitz is obvious.

II

The immediate background of theory and experiment up to

* The *Minimum Visibile* seems to have been a term in use as far back as Berkeley (**7**), whose use of the term indicates one of the first attempts to describe a threshold value of a stimulus.

1916, from which research upon subliminal impression has arisen, has been summarized by Coover (**16**)*. This summary and other contributing sources, together with the more recent experimentation, may be presented under the following classificatory heads:

1. Types of phenomena of a "telepathic" nature.
2. Experiments indicating hyperaesthesia.
3. Phenomena of the "subconscious".
4. Data from psychophysical experiments.
5. Laboratory experiments directly concerned with the influences of the subliminal stimulus.
   (a) Experiments with the Mueller-Lyer illusion.
   (b) Influence of the subliminal stimulus upon guessing.
   (c) Coover's experiments upon the effects of subliminal impression.
   (d) Attempts to condition experimentally a subject's response to a subliminal stimulus.
   (e) Experiments showing alteration of thresholds by the introduction of auxiliary stimuli.

Only brief reference is possible to the representative literature under these headings.

1. *"Telepathic" phenomena:* Telepathy implies the communication of "minds" through extra-sensory channels. Collusion and the infinitesimal probability of chance coincidences accentuated by wishful thinking explain many cases. The remaining instances are usually accounted for by the giving and receiving of unintended signs. As examples of how information may be transmitted unwittingly from one individual to another within an immediate situation, reference is made to the "autoscopes" (magic pendulum, ouija board, small table for table-tapping, etc.) described by Barrett (**3**) and the muscle reading experiments described by Stratton (**66**). Both the "autoscopes" and the muscle reading depend upon slight motor accompaniments to thought processes. Stratton found that the ability of a subject

* Since this monograph was initially prepared an additional review of part of this material from the point of view of ESP has appeared. See Kennedy, J. L. (**43**).

to find hidden objects, to place them in strange positions, and to adopt a directional set depended, in part, upon visual aid from signs that were unintentionally given.

> "These signs were exceedingly obscure, rarely evident to the experimenters watching the guide. [The guide was the one who held one end of a stick or chain, the other end was held by the subject.] . . . The hints seem to have come from fleeting glimpses of the guide's changes of place and posture caught in the very margin of vision and perhaps without any conscious intention by the subject to notice or use them" (**66**, p. 314).

Münsterberg (**54**) described the "mind reading" of Beulah Miller as the result of her "subconscious noticing of unintended signs" (p. 162). The "educated" horse, Clever Hans, could tap out answers to difficult mathematical problems only when his trainer was in the field of vision (**57**). The tapping was evidently guided by imperceptible changes in the trainer's posture. Pillsbury (**58**) analyzed parlor games of "mind reading" as being dependent for their successes upon slight signs or cues unwittingly given and received.

The experiments by J. B. Rhine (**59**, **60**, **61**) appear to give evidence of perception independent of sensory avenues. This "finding" is, of course, not a new one; psychical researchers for several generations have boasted of similar "experimental" results. Since the conditions of such experiments have seldom, if ever, met the rigorous requirements of the scientific laboratory, the results have been viewed with suspicion. Coover's (**16**) researches, designed to discover if possible the bases of telepathy and clairvoyance within natural modes of stimulation, found that one of the principal sources of such influences was the subliminal stimulus. The recent review of the extra-sensory perception literature by Kennedy (**43**) points out the possible systematic errors of the ESP methods. These are more numerous and elusive than investigators have usually suspected. Such criticism should have a constructive effect not only on further ESP research but also on methods of control in other lines of psychological research. Repetition of these experiments in other laboratories, for example, by Baker (**1**), has failed to corroborate Rhine's results. Critical analyses of the statistical procedures by Kellogg (**41**, **42**), Herr (**36**) and Goodfellow (**32**) have con-

siderably weakened the arguments for an ESP process. Rhine's own confession of temperament and desire (**61**) lead one to wonder if his methods adequately protect the data and conclusions from the experimenter's bias. If, however, the statistical procedures are valid and extra-chance factors of some sort are indicated, it should not be necessary to interpret such factors in a way that immediately associates them with telepathy, clairvoyance and other spiritistic notions. It would seem wise systematically to eliminate all possible factors of the natural order, including factors of method that might bias the data, before suggesting an explanation involving another, and perhaps fictitious, order of phenomena. Certainly there should be some agreement among independent investigators as to methods and results before a new order of phenomena is postulated. Until it is clear that subliminal stimuli, mental habit, infinitesimal probability, inappropriate use of statistical formulae, collusion, and uncritical enthusiasm on the part of the experimenter have been ruled out, extra-sensory perception must be doubted. It would appear that any enthusiastic foray upon a field so full of unknowns, pitfalls, and historical embarrassments must almost inevitably be a Don Quixote attack.

2. *Experiments indicating hyperaesthesia:* Bergson (**5**) reported the case of a hypnotized subject who gave evidence of responding to reflections from the cornea of the experimenter's eye. The calculated height of the reflected image was less than 0.1 mm. Bergson does not give the distance between experimenter and subject, but, assuming it to be a convenient distance of about 16 inches, the height of the retinal image would be about .004 mm. It seems doubtful that any contour discrimination would be possible under these conditions.

Verrall (**70**) performed an experiment in which she guessed suit and rank of playing cards after placing the pip against the inner edge of her left thumb. The four hundred guesses recorded show that her right guesses were significantly in excess of chance. Correct guesses were also significantly in excess of chance when she looked at the backs of the cards, but right guesses decreased when she closed her eyes. She suggested that impressions from

printing may have produced differences on the backs which were subliminally perceived.

Jastrow and Nuttall (**39**) obtained 800 judgments from a subject upon the presence or absence of a magnetic field from an electromagnet. Correct responses were definitely in excess of chance. They found, however, that their subject was probably responding to a subliminal auditory click which accompanied magnetization.

3. *Phenomena of the "subconscious":* Jastrow (**38**), in his book *The Subconscious,* indicated three types of activities in which subliminal stimuli are supposed to play an important part. These are (a) feelings due to organic conditions, (b) mass impressions, and (c) the psychophysical judgment. The last of these will be referred to in the paragraphs immediately following.

(a) Considering physiological functions which normally give rise to few or no sensations, Jastrow pointed out that, when the normal balance of function has been disturbed, "all sorts of sensations more or less vaguely localized and indefinitely realized and difficult to describe make themselves known" (**38**, p. 10). This complex of individually imperceptible sensations combines to produce a particular feeling tone or disposition.

(b) This impression of one's own well-being from unanalyzable afferent sources has its analogue in the mass-impression obtained from types of stimuli combinations outside oneself. Jastrow said that the tendency to appraise effects as a whole is characteristic of many perceptual experiences. For example,

> "In judging the tone-quality of a piano, the color harmony of a wallpaper, the mass-impressionism makes the first appeal, and for the layman possibly the sole appeal" (**38**, p. 425).

The quotation illustrates the recognition that qualities and meanings of perceptual experiences may be modified by many subtle, unanalyzed or subliminal influences.

That the processes of association may be influenced by connections unconsciously made has been shown by Sir William Hamilton (**33**), Scripture (**62**), Bergström (**6**), Hylan (**37**) and Coover (**15**).

4. *Data from psychophysical experiments:* Peirce and Jastrow (**56**) have argued that due to these subliminal influences there is no *Unterschiedschwelle.*

> "If there be a least perceptible difference, then when two excitations differing by less than this are presented to us, and we are asked to judge which is greater, we ought to answer wrong as often as right in the long run. Whereas, if the theory of least squares is correct, we not only ought to answer right oftener than wrong, but we ought to do so in a predictable ratio of cases" (**56**, p. 75).

This is, of course, another way of stressing the statistical nature of the limen, although that was not the purpose of Peirce and Jastrow. The results of their investigation indicate that imperceptible differences between stimuli may significantly influence judgments.

Stratton (**65**) has pointed out that below the j.n.d. "although we cannot perceive a distinction here, a mental difference really exists" (p. 86). He illustrated the argument by saying that weights of 100 and 104 grams are distinguishable, but might appear to be the same if we compare 100 g. with 102 g. and then 102 g. with 104 g. Since the first is like the second and the second like the third, the first might be inferred to be like the third. There are real mental differences here or the 100 g. and 104 g. could not be distinguished when compared. This argument is similar to that of Sir William Hamilton that a *Minimum Sensibile* is still effective even though the influence is too subtle for conscious detection.

Culler (**17**) stated that when *O* reports that he is entirely uncertain of his judgments he is more often right than wrong. This point appears to be in direct contradiction to the argument that "guessing" distributes at random. Strictly speaking, if the responses do not distribute at random, they are not "guesses".

Studies of cutaneous sensitivity below the two-point limen indicate how, in one sense modality, cues may be used for biasing judgments of stimuli supposed to be subliminal. Judgments based on similar subliminal processes exist for the other modalities, but this type of cutaneous experiment expresses the fact clearly. The technique requiring a rigid separation of sensory

attitude from stimulus attitude is probably the essential condition for this result—the result that a limen found by the sensory attitude may be considerably altered if one uses cues derived from a stimulus attitude. Kottenkampf and Ullrich (**44**), in their studies of sensation below the two-point limen, spoke of the impression that the skin was being touched by an elongated body. Leuba (**50**) pointed out that the passage from oneness to twoness is through a sensation of length. Binet (**8**) noted special perceptive forms between the one and two point experiences, while Foucault (**29**) distinguished as many as six intermediate forms. Gates (**31**) described three definite patterns which lay between the extremes, namely, line, circle, and dumbbell. Friedline (**30**) has shown that changes from the psychological attitude to an "everyday" attitude are sufficient to "account for differences of numerical results that have hitherto been ascribed vaguely to practice and fatigue" (p. 401). Typical of the subliminal patterns reported were line, short line, dumbbell, double-paddle, oval, oblong, rectangle, and bar. That subliminal separations, giving rise to definite forms, serve as cues for discrimination is evident from an experiment by de Laski (**19**). He found that when the two-point experience was not clear judgments subliminal to this could be made in terms of long line, blunt line, spot, dumbbell, etc. Such cues are not usually so dramatically evident in other sense modalities, but that the organism responds differentially to subliminal patterns appears evident from experiments.

5. *Laboratory experiments directly concerned with the influences of the subliminal stimulus:*

(a) Experiments with the Mueller-Lyer Illusion:

The first experiment of this type was reported by Dunlap (**21**) in 1900. He noted that,

> "The conscious effect of stimulation of such low intensity as to be imperceptible presents an attractive and almost unexploited field for experimental work" (p. 435).

That the field is relatively unexploited is still true thirty-nine years later. The essential feature of the experiment required the subject to judge line length when imperceptible shadows of arrowheads were cast upon the ends of those lines. The experiment

was repeated a second time under conditions more carefully controlled. The results of both methods indicated a consistent, though slight, effect of the imperceptible shadows upon compared line distances.

Titchener and Pyle (**68**) reported a repetition of the experiment in 1907. With their method it was possible to vary the intensity of the shadows. The data of the experiment indicated (a) that imperceptible shadows had no effect, and (b) that weak shadows were as effective as strong ones.

Washburn and Manro (1908), instead of using shadows, made slight pencil lines for the arrow heads (**71**). These pencil lines were reported to be imperceptible at the distance of the observer. Of the 1370 judgments, which were in terms of only "longer" or "shorter", 700 were in favor of the illusion. Since this number so closely approximated the expected chance frequency, they concluded that the imperceptible lines were ineffective.

The last of the experiments upon the Mueller-Lyer Illusion was performed by Joseph Bressler in 1931 (**10**). He was particularly critical of the experiment by Titchener and Pyle because they had given their subjects much preliminary training. According to Bressler, such training operated to reduce the appearance of the illusion. That this decrease in effectiveness due to supraliminal observations would probably render the subliminal stimulus ineffective appears to be a valid criticism. Bressler's own experiment consisted in choosing a gray background from among the Hering gray series and drawing upon this background a black line for the shaft of the arrow. The arrowheads were made of strips of gray paper that were imperceptible in brightness difference from the background. Three sets of arrowheads were used which represented three grades of brightness difference. Comparing the judgments obtained by a separate series for each grade of brightness, he found that the nearer the arrowheads approached the limen the more the data indicated the effectiveness of the subliminal features.

(b) Influence of a Subliminal Stimulus upon "Guessing":

The work of Boris Sidis (1898) was first in order of a fairly definite series of experiments upon "guessing" (**63**).

Using himself as subject he viewed letters and digits at such a distance that they appeared only as dots. His correct " guesses " were significantly in excess of chance in several parts of the experiment.*

In 1908 Stroh, Shaw and Washburn conducted three experiments similar to that of Sidis. (1) Letters from A to J were exposed at a distance from which the subject saw them only as dots. (2) Letters were enclosed in rectangles and viewed at a distance too great to allow clear perception of contours. (3) The letters were whispered " so softly that no sound whatever could be heard at the distance at which the observer sat " (67, p. 244). In all three experiments the critical ratios were greatly in excess of chance (41.3, 34.2 and 20.6 respectively).† That extra-chance influences were operating is obvious, but that these influences were outside the field of awareness and that the responses were felt by the observers as complete guesses guided by no cue from the stimulus is probably not an accurate description. The chief difficulty in an experiment of this kind is standardizing the subject's conception of a " guess ". Without specific instructions from the experimenter regarding the criteria of a guess, the subject is free to adopt a wide range of attitudes. The result is that what constitutes a guess for one subject may not be a guess for another. An observer may use a slight feature of the stimulus pattern for the purpose of narrowing the range of objects from which the selections are made. For one this may mean a partial recognition that is not strictly a guess; for another, who adopts a less critical attitude, this may pass for a guess. The situation here may be similar to that described in the experiments upon the cutaneous two-point limen. This uncritical attitude may explain the fact that in Series I the range of correct percentages among the 13 subjects was from 16% to 74%; in Series II, 8% to 67%; and in Series III, 10% to 39%.

* For a critical analysis of Sidis' statistical treatment the reader is referred to Coover (16, p. 180).

† Critical ratios are not given in the article. They may be derived by the application of the formula for σ of the binomial expansion which is $\sigma = \sqrt{pqn}$, where p = probability in favor of the event, q = probability not in favor, and n = number of events in the series.

Coover (**16**) criticized the above experiment. He was doubtful about the use of the theoretical 10% as the expected frequency by chance. He classified the letters from A to J into three groups on the basis of cues which the subject might use. If these cues can be used by the subject in limiting his guess to the appropriate group, then the theoretical chance frequency is not 10%. Below is Coover's classification (p. 188):

B E H—full, heavy appearance of the blurred stimulus,
Chance — .33

C G D—rounded, open appearance of the blurred stimulus,
Chance — .33

I J—long, narrow appearance of the blurred stimulus,
Chance — .33

Assuming that A and F remained as wholly indefinite stimuli, Coover found that by this classification the chance of R cases is raised to 32% providing, of course, that the subject used such a method of guessing. In this connection it is of interest to note that the frequency of correct guesses dropped in Series II. When the letter was enclosed in a rectangle the available cues for differentiating the patterns apparently decreased. These criticisms are not intended to indicate that subliminal stimuli may not operate as part of the conditions of a response, but that to control these stimulus effects experimentally is extremely difficult.

Baker (**2**) studied the influence of subliminal stimuli upon verbal response when the intensity of the stimuli was below a "confidence" limen. The subjects rated degree of confidence in their reports regarding the nature of visual and auditory stimuli. Intensity of stimulus was reduced in steps until the subject rated 100% of his judgments as "pure guesses" or as being associated with no degree of confidence. Even though the intensity of the stimulus was still reduced several steps below this point the subjects' guesses were correct in a greater number of instances than chance expectancy.

(c) Coover's Experiments upon the Effects of the Subliminal Impression:

Coover's experiments (**16**), the most extensive concerning the effects of a subliminal stimulus, will receive special attention

because they have furnished a point of departure for the present research. His interest in the effects of subliminal stimuli was aroused by directing experiments in Psychical Research. The so-called "psychic" individual usually explains his performance by a theory dependent upon extra-sensorial communication of knowledge. Coover's experiments indicate that (a) if communicator and recipient have complete sensory isolation from each other there is no transfer of information by extra-sensory channels; and (b) without this isolation recipients may be definitely influenced by subliminal impressions that are unwittingly given by the other person.

This review, however, must be confined to his experiments upon subliminal impression (**16**; Part II). This research was more definitely controlled than were any of the previous experiments of a similar character. Time intervals for stimulus presentations were controlled by the tachistoscope. Stimuli were uniform; stamping or printing devices were used. The distance of the observer was recorded. The attitude of the subject was controlled by definite instructions.

The research was divided into four parts. In Division I the stimuli were five letters and five digits printed in black upon white by rubber Roman type 21 mm. high. They were presented to foveal vision by a Wirthian tachistoscope with the observer four meters distant. Time intervals of exposure were about three to seven milliseconds, with the usual time at about four milliseconds. The observer was instructed to underscore twice the characters definitely perceived, to underscore once the partially perceived characters, and not to underline a mere guess. In one series the subject included in his possible guesses the whole alphabet and the ten digits. In the other series instructions were given to confine guesses to the ten characters actually used. In the former case the probability *(p)* of R guesses was 1/36, while in the latter *p* for R guesses was 1/10.

The principal material of these two series may be summarized in the following table:

G = Guesses on particular character
R = Right guesses
P = Probable number of R guesses by chance
x = Excess of R guesses above chance
σ = Standard deviation of R guesses by chance, using formula $\sigma = \sqrt{pqn}$
x/σ = Statistical Reliability

	G	R	P	x	σ	x/σ
Series I	1809	170	51	119	7	17
Series II	459	60	46	14	6.4	2.2

The experiments of Division II differ from those of Division I in only four respects: (1) A Wundtian tachistoscope was used, (2) stimulus characters were produced by the elite type of a Remington Standard typewriter, (3) subjects sat two meters distant from the stimulus card, and (4) time interval was 85 milliseconds. There were two series as before, one in which *O* used the whole 36 letters and digits for his guesses, and the other in which he confined the guesses to the ten characters used. Similar results were also obtained in that extra-chance influences were far more obvious when *O*'s choices were not confined by instruction to the ten characters actually used.

Coover pointed out two possible sources of error which might account for this difference between Series I and II of each of the above experiments. The first is in the influence of "mental habit" upon judgment. He described, in part, what he meant by "mental habit" in the following way:

> "The field of error is curiously limited in a reagent's guessing; limitation is involuntarily self-imposed. Since these limitations vary with the individual, unless there is a common influence upon them, they have no effect, in the long run, upon the per cent of R cases.* Were they subject to the influence of subliminal impression they would contribute to R cases, and in two ways: (1) by canceling error in the direct subliminal perception of the particular character; and (2) by limiting the range of error, in some degree, to the symbols exerting the influence and thus increasing the chances for R cases apart from either the immediate subliminal perception or pure chance. This second form of augmenting the R cases of chance, however, may also result, and perhaps more effectively, from occasional satisfactory perception of the symbols. . . ."
>
> "A second source of error, one likely to be pressed by the experimental psychologist, is the lack of a guarantee that all the guesses are valid guesses" (pp. 201, 203).

* See Coover's "Experiments in Psychical Research" (**16**, p. 308f) for a consideration of the influence of "mental habit on judgment". This concept will be further elaborated in connection with a statistical method for its correction (p. 49f).

The above quotations indicate that Coover was aware of the principal sources of error that are encountered in this type of experimentation. He dealt with each of these separately and to the writer it appears that he answered adequately each possible criticism.

The purpose of the experiments in Division III was to present stimuli to peripheral vision. These experiments did not permit the occasional perceptions, partial and complete, that appeared in the former experiment. This procedure was, therefore, free from criticism that the introspective check by a naïve observer might be unreliable in discriminating between guesses and partial perceptions.

Each exposure card carried two symbols, a capital letter in the lower right hand corner and a digit in the upper left hand corner. This separation of digit and capital subtended an angle of eight degrees at one meter, the distance of the observer. The visual angle of the character itself was 8.6 minutes. Exposure duration was 85 milliseconds. The subject was required to record the capital observed during the exposure, and with it any digit that came to mind. He was warned not to use any system in controlling his selection of digit. Accurate determination of the capital was sufficiently difficult to require close fixation. There was an essential difference in subjective conditions between this experiment and those preceding. The observer worked without knowledge of the peripheral feature of the stimulus pattern. In 90% of the cases the capital letter was observed correctly; only these were used in determining the extent of subliminal or unnoticed impression. Of the 2364 guesses on digits, 365 or 15.44% were correct. By using the formula $\sigma = \sqrt{pqn}$, we find a critical ratio of 8.8. After correcting for "mental habit" as a source of error, Coover found that R cases are 2.02 times the chance limit. This limit of chance adopted by Coover was $p = .9999779$ which, when converted into critical ratio units, is about 4.2. Twice this deviation is similar to the deviation indicated above. That is, $2.02 \times 4.2 = 8.4$ which is nearly 8.8. "Mental habit", evidently, did not affect these results significantly.

The experiments upon peripheral vision were extended to include three other series. Those series differed from the preceding and from each other only by the eccentric distance of the digit in peripheral vision. Series 2, 3 and 4 presented the digit at 6 degrees, 4 degrees and 2 degrees, respectively, from the fixation point. In Section I these series were made with the subject uninformed of the peripheral digit; in Section II the same four series were repeated with the subject making an effort to see the digit. These experiments are summarized in the table below.

	Section I				Section II			
Series	1	2	3	4	1	2	3	4
Visual Angle	8°	6°	4°	2°	8°	6°	4°	2°
No. Subjects	26	15	14	14	9	9	9	10
Items of data	2364	721	403	276	240	261	175	195
% Digits R	15.44	12.07	12.65	21.76	21.7	24.2	28.0	47.2
x/L	2.02	0.36	0.32	1.27	0.20	0.50	0.70	2.80

L, the chance limit adopted by Coover, is described above.

The experiments of Division IV were concerned with subliminal impressions from (1) corneal reflection, (2) cards viewed at a distance, (3) whispering of the stimulus, and (4) involuntary signs.

(1) Evidence that one may be biased in his responses by the pattern of light reflected from the cornea of another individual should be of interest not only to the experimental psychologist but also to the social psychologist. Subjects were required to underscore perceptions and to record guesses without underscoring. Results indicate that when the observer is about two feet from the card-reflecting cornea there is a large percentage of underscored records. Only the guesses were used in determining the extent of subliminal impression. R cases are sufficiently frequent to be 2.9 times the chance limit.

(2) Nine hundred responses were recorded from seven subjects who viewed playing cards at a distance. Frequency of guesses on color showed R cases 2.3 times the chance limit, which the R cases on suit were 1.28 times the chance limit. The principal source of error in this experiment, as Coover pointed out,

is the fact that cards with more spots show up color more distinctly.

(3) Following leads suggested by Stroh, Shaw and Washburn, Coover included whispering experiments. He indicated his reasons, however, for so doing in the following statement:

> "An explanation offered in the early days for the successful experiments in Thought-Transference was the unconscious perception of involuntary whispering, and recent experiments have strongly suggested that the whispering of letters increases R cases in guessing even though the reagent hears no sound" (**16**, p. 219).

In these experiments the whispering of the character was made at a distance of 25 meters. Records were made only after an intensity of articulation was found which was judged to be below the limen of intensity. Five letters and five digits were used. One series was made in which the subject thought any of the letters of the alphabet or digits might be whispered; the other series was conducted with the subject informed of the particular set of characters used. Four hundred guesses were made in each series. In the first series, right guesses are 1.12 times the chance limit; in the second, the x/L value is only 0.29. Extra-chance influences are evident in the first, but lacking in the second.

The objection to this type of experimentation for studying effects of subliminal impression is the inability to standardize the intensity of the whispered stimulus. This kind of experiment was important, however, to Coover's purpose which was to find the conditions of "thought-transference" within natural modes of stimulation. As evidence of subliminal impression his method protected the data. Of the records double underscored (perceptions) only 65% were right; of those once underscored (inferences) 39.6% were right. The guesses were, therefore, from stimuli below the conventional limen of 50% correct (**16**; pp. 211 and 221). Experiments in which playing cards were whispered did not yield a sufficient number of R cases to indicate any extra-chance influence.

(4) One of Coover's students was found to have a number-space synaesthesia. Acting as experimenter, she closed her eyes and thought of a number. A subject, confidentially informed of the number-form system, endeavored to guess the number

thought of by observing the movement of the cornea under the experimenter's eye-lids. In spite of the subject's own skepticism in using such cues, her right guesses show definite extra-chance influence. Her skepticism was taken as an indication that the assistance derived from the involuntary signs of the experimenter was subliminal in character.

(d) Attempts to Condition Experimentally a Subject's Response to a Subliminal Stimulus:

Newhall and Sears (**55**) appear to have demonstrated that a finger retraction may be conditioned to accompany a light near the absolute threshold. Evidence is also present which seems to indicate that finger retraction, in several instances, followed a subthreshold visual stimulus, the subject reporting that he had not been aware of the light. The purpose of the study was to contribute a method of determining thresholds for both animals and human beings on the basis of the conditioned response.

Cason and Katcher (**12**) failed to obtain evidence that a conditioned response may follow a subliminal stimulus. They were primarily interested in learning theory and the necessary modifications in theory if it were found that changes in behavior of which the individual was not aware could be conditioned by stimuli of which he was also not aware. The fact that breathing and blinking rates were not significantly affected by the stimuli used does not mean that critical variations in method might not be accompanied by positive results. The authors concluded the report by suggestions for such variations.

Silverman and Baker (**64**) attempted to condition an increase in breathing, an increase in the frequency of the eyelid closure, and an increase in foot pressure on a pedal to a subliminal electric stimulus. The breathing and foot pressure responses failed to be conditioned; the eyelid response was conditioned to the subliminal stimulus in three out of twelve subjects.

(e) Experiments Showing Alteration of Threshold by the Introduction of Auxiliary Stimuli:

Kravkov (**45**) and Hartmann (**34**) reported that the visual acuity of one eye is increased when the other is simultaneously

stimulated by a bright light. General features of the two experimental situations were similar. The observer was required to report when two movable illuminated squares were just noticeably separated, and when they were no longer separated. When the squares were subliminally close, the stimulus object appeared as a homogeneous rectangle. When supraliminally separate, they appeared as two distinct squares. In one series the subject observed the test object with monocular vision and without an auxiliary stimulus in the other eye. The second series introduced the variation of a bright light stimulus to the previously unused eye. Concomitant effects of the auxiliary stimulus are a slight, but consistently lower, threshold.

In a second experiment, Hartmann (**35**) extended this study of intersensory relationship. His purpose was to investigate some of the reciprocal relations among the visual, auditory, olfactory, and tactual senses. The same type of test field was used. Results from the simultaneous stimulation of other sense modalities are in accord with the data of the previous experiment. The threshold seems to be invariably lowered.

Beitel (**4**) found that within critical angles of separation two small patches of light will have lower threshold values than when they are exposed separately. Within this critical angle, decreases of separation are accompanied by decreases of the threshold. The evidence seems to indicate reinforcement effects of subliminal stimuli.

Karn (**40**), in an experiment similar to that of Beitel, exposed two patches of light. Threshold values were obtained for the one patch while the brightness of the other was varied within the subliminal range. He found that decrease of the threshold was proportionately related to increases in the subliminal intensity of the auxiliary patch.

Preliminary Survey of the Experiments

The present research is reported as a series of three experiments. In the first two experiments the six geometric forms were presented tachistoscopically to peripheral vision; in the third, the forms were applied to the skin of the forearm simultaneously with the visual stimulus.

In Experiment I an attempt was made to determine a subliminal size of the geometric form when it appeared at seven degrees below the fixation point on the vertical meridian. In Experiments II and III the subject did not know that a form was being presented in peripheral vision. The form was unnoticed as well as subliminal. The general purpose of Experiment II was to determine the effect of varying the size of the subliminal form stimulus upon the subject's frequency of correct choices when the choices were confined to the set of six forms. In Experiment III, the subliminal form patterns were presented both visually and cutaneously. The object of this series was to study the relationships that might exist between subliminally aroused processes from two different sense modalities. With each experiment the respective objectives will be described in more detail. The following table shows the number of subjects and the number of records in each experiment:

TABLE I

TOTAL NUMBER OF SUBJECTS AND EXPOSURES

Experiment	Subjects	Exposures
I	7	1152
II	10	2160
III	29	6111
Totals	46	9423

APPARATUS

The apparatus for Experiments I and II consisted essentially of two parts, a mirror tachistoscope and a device for timing the exposures. The tachistoscope was a light-proof box structure. General details of this part of the apparatus are shown in Figures 1 and 2. The distance from eyepiece to the exposure screen was fifty-six inches. The inside dimension of the cross-section was 18″ x 18″. Across the main chamber, a piece of thin plate glass was set at a forty-five degree angle so that, when lights in the side compartment (note Figure 2) were on, a fixation screen was reflected to the observer. This same glass allowed a direct transmission of light when the exposure card at the end

of the tachistoscope was illuminated. Exposures were made by alternating the lights between the compartment and the end.

The Bergström Chronoscope served as a timing device in Experiments I and II. Two trip-contacts were set at a 90 milli-

FIG. 1. External side view of the tachistoscope with the exposure card partly withdrawn.

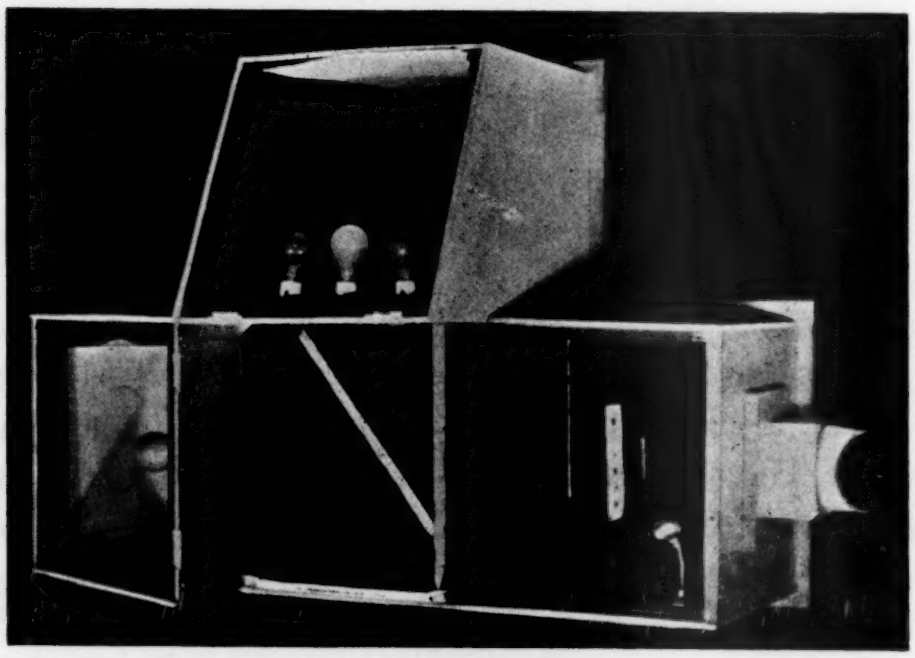

FIG. 2. Top view showing internal construction of the tachistoscope.

second separation and each was wired in series with a relay. The relays, which were activated during a swing of the pendulum, controlled the momentary shift of illumination in the tachistoscope. As the pendulum struck the first trip-contact, the circuit

for lights in the side compartment was broken while the circuit was made for lights in the end. When the pendulum tripped the second contact, the reverse of this took place, *i.e.,* illumination of the exposure card faded, while the pre-exposure card came again into view. This latter card remained visible until the next exposure.

The mirror tachistoscope has several advantages. Presentations of stimuli are nearly noiseless; there is no real or apparent movement of any part of the apparatus at the moment of exposure; illumination may be adjusted so that no change is detected between pre-exposure and exposure fields. The electrical control of exposures, while not an exclusive feature of this type of instrument, is also an advantage of the mirror tachistoscope.

During Experiment III a motor-driven set of commutators, constructed of hard rubber with brass insets, was used for alternating the lights. Length of metal insets and speed of commutators were adjusted to give the 90 millisecond exposure interval used in Experiments I and II.

In Figure I a black cloth hood may be seen above the eyepiece. During an experimental sitting this hood was let down about the subject's head to eliminate influences of light from outside the tachistoscope. The exposure card which is partly shown in this figure consisted of three parts mounted upon a wooden frame which might be removed part way from the tachistoscope for adjustments between exposures. A square piece of white cardboard was placed between two circular pieces. The larger circular piece is almost entirely concealed in the picture. The arc at the left shows an edge of this card upon which were drawn the six geometric forms. All forms were placed at 6.85 inches from the center and subtended an angle of 7 degrees at 56 inches. A small opening in the middle card was placed at this same distance below the center on the vertical meridian. As the card bearing the forms was rotated, each form might appear singly in the small opening. This arrangement avoided the disadvantage of inserting separate cards for each exposure.

To the observer's eye the black spot in the center of the exposure card corresponded in position and size to the fixation

point of the pre-exposure screen. The pre-exposure screen or field, reflected from the compartment on the right side of the tachistoscope, was entirely blank except for the fixation point in the center of the card. Illumination was made by lights on the ordinary 110 volt circuit.

Figure 2 shows the exposure card in position for an observation. For the fixation screen to appear equal in brightness to the exposure card, about four times as much light was necessary in the side compartment because of the absorption of light by the glass and the low degree of reflection. Three 60 watt lights were used in the pre-exposure chamber while one 40 watt light gave the illumination for the exposure card. To avoid the effects of light reflected from the walls of the tachistoscope, the inside was painted black. In addition to this, partitions were inserted with the center openings just large enough to allow a full view of the exposure card. The *Landolt Circle* (**47**), which may be observed in Figure 1, was used only in Experiments II and III.

Experiment I

A. Purpose. Experiment I dealt entirely with the tachistoscopic exposures of the geometric forms. The purpose was to determine the size of form that, under the conditions of the experiment, would be below the limen * of recognition. The conventional psychophysical methods were abandoned for the following reasons: (1) The psychophysical methods available require judgments from the subject in terms of "the presence or absence" of the sensation or in terms of "more than", "equal to" or "less than" a standard. In the present experiment the question was not "whether" or "how much", but rather "which" stimulus was present. When the problem is to identify a type of stimulus from among several other types of stimuli, these traditional methods do not apply without considerable modification. (2) The purpose of the experiment was not to determine a limen for each of the forms used, but to discover a size which was definitely below any threshold of recognition.

* The term "limen" as used in this discussion will not connote the usual statistical concepts implied from psychophysics. The term will be used in the sense of a "limit", however.

B. Subjects. There were seven subjects tested in this preliminary experiment. Two of the observers were members of the staff of the Northwestern University Department of Psychology. Two observers were graduate students in the same Department while the remaining three were undergraduate students.

C. The Experimental Situation and Method. The method of this first experiment presents many features in common with the two experiments that follow. For this reason the procedure is described according to details to which reference may later be made.

1. The Controlled Variable. The only controlled variable in this experiment was the geometric form pattern, of which there were two aspects, namely, shape and size. The forms were circle, hexagon, square, diamond, triangle and cross. Their size was equated according to the length of the main dimension. Three sets of these six forms were used. The first set had a main dimension of 10 minutes of arc at a distance of 56 inches; the second set subtended an angle of 15 minutes, while the third had an angular main dimension of 30 minutes. Separate exposures were made for each form.

2. Features of the Experimental Situation Held Constant. For the sake of completeness the features of the experimental situation which were held constant may be enumerated as follows: (a) illumination, (b) position of the geometric form, (c) brightness of forms (solid black upon a white background), (d) exposure time (90 milliseconds), (e) attitude of the subject (by means of instruction), (f) effects of practice (preliminary training and counterbalanced stimulus series), and (g) distraction and fatigue.

As far as possible, by the use of instructions and suggestions, the attitude of the subject toward the experiment was controlled. When the subject came to the experimental room for the first time he was given a brief explanation of the apparatus and the following set of instructions were read to him.

"As you look through the eye-piece of the tachistoscope you will see a plain white screen; in the center of this screen is a black dot. This is your fixation point. When an exposure is made, another screen will appear in place of this one and identical to it with one exception; a few inches below the center there

will be one of these six geometric forms. (The subject was then shown the set of forms on another card.) It will be your task to decide which form is being exposed, how certain you are of it, and why you made the choice. Before each exposure you will be given the signal 'ready' which will mean for you to get your eye directed upon the fixation point. You are to hold this fixation constant until after the exposure is made. Report any known losses of fixation. There will be three things for you to do after each exposure. (1) Name the form you think was present. (2) Give a rating of your certainty of judgment. This subjective rating may be done in the following manner. If you have no doubt whatever regarding your report, give it a rating of 'one'; if, however, your choice is accompanied by so great a feeling of doubt or uncertainty that you would as soon leave your decision to the toss of a coin or the roll of a die, you should rate the judgment 'five'. Feelings of some certainty accompanied by doubt or hesitation may be rated 'three'. You have left 'two' and 'four' which you may use as intermediate steps. (3) The third part of your report is in giving the identifying feature of the form which you have used in making your judgment. In case your rating is 'one', 'two', 'three', or 'four' you should be able to report some detail which served to direct your choice. Only in cases of no identifying feature should you use 'five' as a rating. On the other hand, do not report identifying features and higher degrees of certainty if you do not experience them."

These instructions were further amplified by as much discussion as seemed necessary for the individual subject. The subjects, all of whom were students from the psychological laboratory, were given an hour of preliminary training.

3. Presentation of Stimuli. Since there were six variations of the form pattern, the exposures were given in multiples of six. At one sitting a subject was usually given 36 exposures; occasionally, if the subject showed no signs of fatigue, 72 exposures were made. The average time required for a set of 36 reports was about twenty minutes. The six forms appeared six times each in a set of 36 exposures and were given in a random order.

In regard to the attitude of the subject, the importance of the random order of presentation should be emphasized. Stimuli near the threshold often invite fabrication in the direction of expectation. The subject must be kept in complete ignorance of what the next variation of stimulus will be. Were the subject allowed to organize an "expectational set", he would limit his range of guesses to less than the full number of six forms used. If the procedure of the experiment gave the subject any valid reason for his expectation, then his probability of right guesses would be greater than 1/6. Since the subjects reported that no such attitude of expectation developed, it was assumed that

the attitude of the subject from this point of view was " held constant ".

4. Sources of Error. (a) Losses of fixation. The principal source of error in this type of experiment is loss of fixation. This was reduced to a minimum by adopting a time interval of exposure shorter than the latency of fixation changes. Under these conditions, if the subject is observing the fixation point at the time of exposure, it is assumed that fixation does not change during the exposure. This assumption is probably not always warranted. The subject may be fixating properly as the exposure begins, but his shift of fixation may begin at the same time. This would allow a clearer view of the stimulus object than is compatible with the purpose of the experiment. The experimenter endeavored to control this source of error in two ways: (1) The subject was informed that he would have a tendency to do this if he allowed his curiosity to develop in regard to the form being exposed. To reduce the factor of curiosity he was told that he might see his records after he was through serving as a subject. (2) The time interval between the " ready " signal and the exposure was varied. This procedure, derived from the reaction time experiment, seems valid for controlling anticipatory responses.

(b) Changes in criteria of judgment. There were probably effects of practice that could not be controlled by counter-balancing the order of size of the presentation of the forms. Effects of this kind were not a serious handicap in realizing the purpose of the experiment. If precise measurements of a threshold function had been desired, the effects of practice would be a real source of error. The stimulus attitude characterized the " set " of the subject and, when this is true, there is a greater tendency to use cues and partial perceptions for directing a judgment. The instructions indicate how an attempt was made to control this tendency.

5. The Control Series. Certainty ratings were not trusted at face value. Since the subject might name identifying features merely because he thought he " ought to see something ", a control series was introduced. This series consisted in exposures without a stimulus-form being present. These blank exposures

came at varying intervals during the regular sitting. The observer was never informed that occasionally no form would appear. He continued to give ratings of certainty and identifying features if any were " seen ".

D. Results and Discussion. The data of Table II show the average certainty rating corresponding to each of the three sizes of forms and the control series in which no form appeared.

Data indicate that subjects were incapable of reporting a guess when, according to the objective stimulus lattern, the response should have been a guess. The Control Series shows that when no peripheral stimulus was presented the certainty average was

TABLE II

COMPARISON OF CERTAINTY RATINGS, EXPERIMENT I

Form Size	Certainty Rating (average)	No. Exposures
10′	4.1	468
15′	4.1	288
30′	3.3	396
Control Series (No form)	4.2	105

4.2. In the ratings summarized by this average, some were as high as " three ". The fact that the observer reported a feeling of some certainty in his judgment, even when there was no objective basis for the feeling, seems to show that, accompanying the guessing attitude rated by " five " in this experiment, the subject had no perceptual awareness of the object. The Control Series included in Table II shows that it was unnecessary to require the limit of uncertainty (*i.e.*, an average certainty rating of five) in determining the size of form definitely below the limit of recognition. It seems reasonable that the size of form that gets the same rating as blank space must be a size sufficiently small to be below any limit of discrimination. On this basis of choosing a size, the 1/4 degree group of forms might have been used in the later work. For the sake of being certain that the form used was small enough to fulfill the requirements of the experiment, the 1/6 degree size was used in Experiment III. The average of the Control Series is of interest also in that it

shows that the subject may lose contact with an item of environment before he realizes it.

Results of Table II corroborate Coover's experimental method by which he required his subjects to record their guesses. In his experiments the subjects indicated three grades of perceptual clearness. If the digit or letter was clearly perceived, the report was underlined twice; partial recognition received one underscore, while guesses were left without an underscore. He used only the guesses in testing for the effects of extra-chance influences due to the subliminal impressions. Guesses so defined by a definite set of criteria are probably seldom accompanied by cues consciously used for limiting the choice. One of the principal objectives of this type of experiment is to study the effects

TABLE III

COMPARISON OF CRITICAL RATIOS, EXPERIMENT I

	10′-size	15′-size	30′-size
No. Exposures	468	288	396
Right Choices (R)	116	119	205
Probable R Choices (p)	78	48	66
R − p (x)	38	71	139
σ	8.15	6.3	7.4
$\frac{x}{\sigma}$	4.6	11.3	18.8
Av. Certainty Rating	4.1	4.1	3.3

derived from cues that are not consciously used. The criteria of the guess in this experiment were more definitely stated than in the experiment by Coover. In Coover's experiments the subject was more free to adopt his own standards of what constituted the non-underscored category; in the present experiment, the observer was not allowed to use the rating of complete uncertainty if he could name any feature about the stimulus pattern that served to limit his range of choices. The latter method should serve to reduce the magnitude of the stimulus even more than the former.

Table III, which includes critical ratios, indicates that frequency of correct responses may be greatly increased without a corresponding increase in the average rating of certainty. Both the 10′-size and the 15′-size have the same average certainty

rating, while the critical ratios for these sizes increase from 4.6 for the 10′-size to 11.2 for the 15′-size. The certainty rating for the 30′-size has increased by 0.8 of a point, while the critical ratio has nearly doubled. It is of special interest in comparing the two smaller sizes to note that an increase in the effectiveness of a stimulus is not necessarily accompanied by a corresponding increase in a subject's feeling of certainty.

Experiment II

A. Purpose. There were three objectives in Experiment II which may be described by the following questions: (1) What will be the effect upon the frequency of correct responses if the observer is kept in ignorance of the presence of the form in peripheral vision? (2) Will there be a concomitant relationship between changes in size of form and frequencies of right cases? (3) What will be the effect of immediate and delayed reports upon correct responses?

B. Subjects. No subject used in the previous experiment acted as an observer in the present one. There were ten subjects, eight of whom were undergraduate students in the Northwestern University Department of Psychology. The other two were graduate students, one in Zoology and the other in Psychology.

C. Method. The methods of this experiment were the same as in Experiment I except for the modifications which follow. In the center of the exposure field there was a small incomplete outline circle * surrounding the position corresponding to the fixation point of the pre-exposure screen. The circle was two degrees in diameter at the distance of the observer's eye (56″). The line composing the circle was drawn with India ink one millimeter wide. The break in the boundary line, making the circle incomplete, subtended an angle of two minutes at 56 inches. For most observers this angle of separation was just above threshold acuity. With longer exposures an angular separation of one minute is more nearly the normal threshold. Since the circle was placed upon a rotary piece of cardboard, the break could be made to appear in any desired quadrant. During the

* Similar to the *Landolt Circle* (47).

experiment eight different positions were used. The instructions to the subject will make clear the use of the circle. These instructions were:

"The purpose of this experiment is to test your keenness of vision. As you look through the eye-piece of the tachistoscope, you will see a plain white screen. In the middle of this screen is a dark spot; this is your fixation point. At the moment of each exposure you will be looking directly at this spot. The exposure presents for a very brief moment the material upon which you will report. This material consists of a small circle surrounding the region of the fixation point. If you attend carefully to this circle you will note a small break in the boundary line. This break is just large enough so you can see it by always being ready at the moment of exposure. A signal 'ready' will be given before each exposure so that you will be sure to have your vision upon the fixation point. Hold this fixation until after the change occurs.

"Report by number, in the following manner, the direction in which you see the opening. If it is straight up it will be number eight; if straight down it will be four; to the right, two; and to the left, six. The intermediate positions will also be used; they are numbered one, three, five, and seven. It will help in remembering if you note that the vertical and horizontal positions are even numbers, while the intermediate positions are odd.

"After each exposure, I should like to have you do just two things: (1) Name the position of the break in the circle. (2) Give the name of one of these geometric forms which comes to mind most easily. (The six forms were shown the observer on another card.) Regarding the form you name, here are some special instructions. It must not only be the one that comes to mind most easily, but it must be a random selection. By random I mean that your choice is not to be influenced by any predetermined notion of what you will say before the exposure is made. Don't think that you must be careful to name a different form each time, and do not make an effort to name them all the same number of times. The principal point to remember is that each successive choice is to bear no relation whatever to any previous selection. Rather, the choice is to be determined by the form which at that moment comes to mind most easily."

Above the opening in the transverse partition closest to the eye-piece of the tachistoscope, a card was placed which bore the six geometric forms. The card was entirely invisible to the observer except when the experimenter illuminated the card by means of a small electric lamp set in this section of the tachistoscope. After each six exposures there was a short pause during which this card was illuminated. The subject was asked to study the card with the purpose in mind that any one of the forms should be as easily recalled as any other.

There were two types of reports, immediate and delayed. In one half of the sittings with each subject, the form choice was

made after identifying the circle position; in the other half, the order was reversed.

In spite of the fact that the subject was warned not to adopt any system in determining the choice of form, such instructions could not prevent a tendency to favor some forms and to avoid others. The piling up of choices on some stimuli with the concomitant neglect of others indicated this preference in response. Coover (**16**) has called this tendency "mental habit". A more detailed description of mental habit, together with a statistical formula for its correction, appears in the section on Statistical Methods.

TABLE IV

THE FREQUENCIES OF STIMULI AND PERCENTAGE OF CORRECT RESPONSES, EXPERIMENT II

Stimulus	10′-size Frequency	10′-size R–%	15′-size Frequency	15′-size R–%	30′-size Frequency	30′-size R–%
Circle	111	19.8	126	15.0	127	13.4
Hexagon	109	13.7	127	7.9	125	17.6
Square	111	30.6	123	27.6	127	20.5
Diamond	99	25.2	128	27.4	126	18.3
Triangle	110	20.0	131	16.0	128	20.3
Cross	108	24.0	131	15.3	122	15.6
Total and Average	698	22.2	766	18.1	755	17.5

D. Results and Discussion. The ten subjects in Experiment II gave a total of 2169 reports which are about equally distributed among the three sets of stimuli used. Tables IV, V, VI, and VII present several items of special interest. The percentage of correct guesses shown in Table IV indicates the greatest number of successes with the square and the diamond although studies of form perception in indirect vision (**14**) would lead one to expect that the triangle would have elicited the greatest success frequency. The successes with the hexagon are, however, consistent with the studies just referred to. It is associated with the lowest percentage of correct guesses.

Table V gives rather curious results in regard to the critical ratios. As the size of form increases, the critical ratios decrease. This is, perhaps, the opposite of what might have been expected. It is also a curious fact that coincidentally Coover obtained similar

TABLE V

THE EXTENT OF EXTRA-CHANCE INFLUENCES FROM THE FORM PATTERNS, EXPERIMENT II

	10′-size	15′-size	30′-size	All Sizes
No. Exposures	648	766	755	2169
Right Choices (R)	144	139	132	415
Probable R Choices (p)	108	128	126	361.5
R − p (x)	36	11	6	53.5
σ	9.49	10.3	10.2	17.3
$\frac{x}{\sigma}$	3.8	1.52	0.58	3.1
With correction for "Mental Habit" *				
$\frac{x}{\sigma}$	4.8	2.34	0.71	

* See page 49 and following.

results, in part, when the subliminal stimulus, presented in peripheral vision, was brought closer to the fixation point in successive experimental sittings. The reader is referred to the data reported earlier.* In Section I of Coover's study, the subject was uninformed of the digit in peripheral vision, while in Section II he made an effort to see it. The procedure of Section I is more nearly similar to that of Experiment II of the present study. Coover's critical ratios, derived from the "procedure without knowledge" series, are largest when the subliminal stimulus is farthest from the fixation point. There is also a marked drop from the six degree and four degree positions with some gain on the final two degree positions. In the present experiment, the critical ratios have a sufficiently similar tendency to warrant comparison. These data may be more definitely compared in the following table:

TABLE VI

COMPARISON OF CRITICAL RATIOS FOR EXPERIMENTS BY COOVER AND BY COLLIER

Coover			Collier		
Eccentric Position of Digit	With Knowledge	Without Knowledge	Size of Form	With Knowledge	Without Knowledge
8 degrees	0.84	8.5	10′	4.6	3.8
6 "	2.10	1.51	15′	11.2	1.52
4 "	2.94	1.34	30′	18.8	0.58
2 "	11.80	5.34			

* See tabular material page 19.

It should be noted that in the one experiment the eccentric position of the pattern is varied, while in the other the size of the pattern is varied. This appears to indicate that the similarity in the behavior of the critical ratios is not due to changes in the functional capacity of the retina alone, but rather to the way in which the perceptual pattern is structured to include or exclude the marginal stimuli.

There were two variations in obtaining reports from the subjects. (a) The subject gave his choice of form after he had reported the position of the circle opening; (b) the subject named the form before identifying the position of the circle-break.

TABLE VII

COMPARISON OF DATA FOR "GUESSING" FORM BEFORE AND AFTER IDENTIFYING CIRCLE OPENING, EXPERIMENT II

(a) The subject gave his "guess" on the form after he had identified the position of the circle opening; (b) "guess" on the form was given before identifying circle opening position.

	10′-size		15′-size		30′-size	
	(a)	(b)	(a)	(b)	(a)	(b)
No. Exposures...	360	288	360	406	431	324
R Choices	95	49	69	70	75	57
p choices	60	48	60	68	72	54
R − p (x)	35	1	9	2	3	3
σ	7.0	6.2	7.0	7.4	7.6	6.7
$\frac{x}{\sigma}$	5.0	0.16	1.28	0.27	0.39	0.45

Table VII indicates a real difference between the two variations as is revealed by data from the smallest form size. When the subject gave his form choice after reporting the material in the center of the exposure card, he increased his right choices considerably. The choices which came first present a correct frequency almost equal to that expected by chance.

Comments from the subjects are of interest at this point. All complained of finding the b-variation more difficult. The task seemed to be increased when the observer was required to remember the circle-break position until after the form choice had been given. Instructions had made the identification of this break position the important part of the subject's task. When he found that forced delay in reporting this position occasionally caused

him to forget it, he became annoyed. Form choice was taken more leisurely and with less effort when the more meaningful part of the report was disposed of first. Whatever effect the subliminal stimulus had was evidently inhibited in the b-variation.

The conditions favoring or facilitating the effects of subliminal stimuli are almost wholly unknown. Experiments cited in the historical section together with the present experiments indicate that subliminal stimuli do modify responses. However, there have been few studies exploring the critical variation of conditions that facilitate or inhibit these effects. The a- and b-variations of the experiment which have just been described suggest possibilities in this direction. There is a suggestion from these data that such conditions as feelings of frustration, irritation, or a complication of the subject's task will inhibit the effects of an unnoticed stimulus, while a more relaxed attitude toward a problem or task may serve to facilitate the effects of unattended stimuli.

According to the data of this experiment it seems evident (1) that unnoticed stimuli operate only under special conditions in modifying responses; (2) that the task "in attention" must be disposed of to some extent before the unnoticed stimuli become observably effective; and (3) that, within limits, smaller patterns or those more in the periphery of vision apparently have a greater effect than larger or more centrally located stimuli when the subject is unaware of their presence.

Experiment III

A. Purpose. The purpose of Experiment III was to observe the effects of presenting simultaneously two similar subliminal stimuli to two different sense modalities, the eye and the skin. The following questions indicate more specifically the details of the objective:

1. Under conditions similar to those of Experiment II, what will be the effect upon the frequency of correct responses of applying a cutaneous pressure stimulus simultaneously with the visual stimulus?

2. If a form stimulus, subliminal in size, is applied to the skin

of the forearm, will it show effects upon the subject's responses similar to the effects produced by a subliminal form presented to peripheral vision?

3. If the areal form of the cutaneous pressure stimulus corresponds to the form presented in peripheral vision, will reinforcement of the two sets of impulses be manifested by an increased frequency of correct responses?

B. Subjects. There were 29 subjects used in Experiment III, only three of whom were graduate students in Psychology; the rest were taken from undergraduate classes in Psychology. All were students at Johns Hopkins University. As in Experiment II, the subjects were kept in ignorance of the nature of the experiment until their observations were completed.

C. Apparatus. The only change in the apparatus was the use of an additional piece of equipment for the presentation of the geometric patterns to the volar side of the subject's left forearm. This device was a metal disc, on the edge of which were mounted the geometric forms cut from hard rubber. The disc was attached to the end of a mounted shaft. Both vertical and rotary movements of the disc could be controlled so that the forearm of the subject might be stimulated simultaneously with the visual exposure by any one of the forms and with a constant pressure. The forms were equated to a main dimension of 10 millimeters. Other experiments (**73, 74**) have shown that, with this size of form, subjects are unaware of a change in pattern when the forms are applied to the forearm.

D. The Experimental Situation and Method. Four variations to Experiment III were necessary to isolate the effects to be observed. The controlled variables together with the features of the situation held constant will be described under each variation.

Variation I: The procedure in Variation I was the same as in the series of Experiment II in which the 1/6 degree size of form was used except that the position of the break in the *Landolt Circle* was always given before the choice of a form. As shown in Table VII, the frequency of correct responses is much higher when this is the order of the subject's reporting. Variation I constitutes a repetition and an extension of this particular series

of Experiment II. For adequate control all subjects serving in Experiment III took part in all four variations so that differences in results from one variation to another could not be attributed to differences in groups of observers.

The instructions to the subjects were the same as those in Experiment II. Since the left arm of the subject was to be in an arm-rest for stimulation in Variations II, III, and IV, the arm was placed in this position during Variation I. Whether or not a change in position of the arm would make any difference in the effects studied in this experiment is not known. The precaution was taken in order to protect the observer from any distractions irrelevant to the experimental variables.

Variation II: Variation II differed from Variation I in only one factor. Factors of similarity included the foveal presentation of the *Landolt Circle* and the peripheral visual presentation of the six forms. The factor of difference was the introduction of a cutaneous stimulus. Simultaneously with the exposure of the visual stimulus the volar side of the forearm of the subject was stimulated with a pressure of 100 grams by the device for applying the stimulus-form to the arm of the subject. The particular pressure pattern used throughout Variation II was the circle. While the initial moment for applying both the visual and cutaneous stimuli was the same, the cutaneous stimulus was allowed to remain in contact with the arm for a period of two seconds. This is the time used by Zigler and Barrett (**74**) who found that when geometric forms were applied to the skin of the forearm approximately two seconds were required before the significant aspects of the conscious experience were completed. While the present experiment made no direct investigation of conscious experience, it was assumed that, if the subliminal process had temporal similarities to the supraliminal process, the application to the skin of the subliminal form should have a duration of at least two seconds.

Variation III: Variation III differed from the preceding series in two respects: (a) No form-stimulus was exposed on the periphery of the visual field. (b) The six geometric forms were presented in varied order to the volar side of the forearm. The

tachistoscopic exposures of the *Landolt Circle* continued as before. From the subject's point of view there was no observable change in the situation and he continued to act under the original set of instructions.

Variation IV: Variation IV was changed from Variation III only by the reintroduction of the geometric form upon the periphery of the visual field. The same form was now presented simultaneously to both the eye and the skin. The significant factors of similarity and difference among the four variations may be summarized in the following manner:

Variation	Visual Stimuli		Cutaneous Stimuli
	Foveal	Peripheral	
I	Landolt Circle	6 forms	
II	" "	6 forms	circle
III	" "		6 forms
IV	" "	6 forms	6 forms

Sources of Error: There was only one added source of error in this experiment not found in the first two experiments. Slight variations were possible in the position at which the cutaneous stimulus came into contact with the forearm. The arm of the subject was held by supports, but was not placed in a cast. Since, however, there was no attempt to correlate responses of the subject with specific cutaneous receptors, this source of error is not significant. According to the results which follow, changes of position were evidently not accompanied by changes in sensitivity.

E. Discussions and Results. Table VIII summarizes the differences between the variations on the basis of the R choices. The excess of R cases in Variation I above that expected by chance alone is sufficient to indicate a definite extra-chance influence. There is less than one chance in 100,000 that the fluctuations in the direction of right choices is the result of chance. The bias toward R cases in Variation II, while less, is still indicative of extra-chance influence. According to the Probability Integral Table, there are 9948 chances in 10,000 that the excess of right choices was not due to chance fluctuations. Conversely, in 10,000 sets of 1326 choices (under these conditions) we should expect 52 of the sets to show this amount of deviation from

TABLE VIII

SUMMARY OF THE RESULTS OF THE FOUR VARIATIONS, EXPERIMENT III

	Variations			
	I	II	III	IV
No. Exposures	1908	1326	1440	1437
R choices	381	253	249	265
p choices	318	221	240	240
R − p (x)	63	32	9	25
σ	16.27	13.5	14.1	14.1
$\frac{x}{\sigma}$	3.88	2.37	0.64	1.77
With "Mental Habit" correction				
$\frac{x}{\sigma}$	4.80	2.8	0.96	2.32
a =	.4999990	.4974	.3315	.4896
2a =	.9999980	.9948	.6630	.9792
p =	.0000020	.0052	.3370	.0208

chance alone. The possibility exists that the results of this series were not biased by the subliminal stimulus. While the frequency of R cases represented here is not sufficient for statistical certainty, there is a fair indication that the results are not due to chance alone.

Under the conditions of Variation III, there is apparently no effect produced by the subliminal cutaneous stimulus. There are 6630 chances in 10,000 that an extra-chance influence was operating, but there are 3370 chances in 10,000 that there was no such influence. The chances for and against the influence of the subliminal stimulus approximate equality. It is, therefore, doubtful that the subliminal stimulus pattern applied to the skin of the forearm produced any influence in the direction of right guesses.

TABLE IX

PERCENTAGE OF CORRECT CHOICES IN FOUR VARIATIONS, EXPERIMENT III

	Variation I		Variation II		Variation III		Variation IV	
	Exposures	R-%	Exposures	R-%	Exposures	R-%	Exposures	R-%
Circle	316	24.4	220	25.0	240	19.6	240	18.7
Hexagon	319	11.3	223	11.2	240	12.5	240	12.9
Square	319	17.5	221	14.9	240	18.3	239	18.0
Diamond	319	21.0	221	22.6	240	20.2	240	19.6
Triangle	316	19.6	220	20.0	240	16.6	239	17.6
Cross	319	26.0	221	20.8	240	16.2	239	23.8
Totals	1908	20.0	1326	19.3	1440	17.3	1437	18.45

Variation IV presents data similar to those of Variation II. In this case there are 9792 chances in 10,000 that the excess of R cases was due to the subliminal stimulus.

The three following inferences appear to be possible from these data: (1) Visual stimuli, not only outside the field of perceptual awareness but also of a sub-threshold magnitude, may, nevertheless, have a measurable differential influence upon responses. (2) A coincident cutaneous pressure stimulus probably operates as a slight inhibition to the subliminal visual stimulus. (3) These particular subliminal cutaneous stimulus patterns by themselves produce doubtful effects.

Unlike the data from numerous other experiments upon dual and multiple stimulation, the data from Variation IV do not give evidence of reinforcement from the combined stimulation of different sense modalities. In this series, the same geometric forms were applied simultaneously to peripheral vision and to the volar side of the forearm. It was expected that facilitation effects might be manifested in a greater frequency of correct responses. There are three possible explanations for the inconclusive result.

(1) The stimulus applied to the forearm not only had no effect as a form stimulus, but operated as a slight distraction. Subjects occasionally reported that the pressure stimulus, coming at the same time as the visual stimulus, seemed to disturb them. They even suggested that this cutaneous stimulus was introduced for the purpose of distraction. In other cases the observers said that after the first few trials they gave no attention to the cutaneous stimulus. The subject's interpretation of this part of the experiment is of interest, but it does not necessarily indicate the type of effect the stimulus produced. The whole experiment deals with stimuli that cannot be adequately investigated by introspection.

(2) The size of the pattern stimulus applied to the forearm was probably too far below the threshold to produce differential effects.

(3) The time relations between visual and cutaneous stimuli may not have been adjusted for the production of facilitation.

The data of Variation III, in which the forms were presented only to the skin, indicate little, if any, effect from the subliminal stimulus. This series does not necessarily demonstrate that subliminal stimuli applied to the skin are ineffective. A change in the size of the forms or a variation of other parts of the procedure might have been necessary concomitants to the manifestation of effects from such a stimulus. The size of the form was perhaps too far below the limen of discrimination. Zigler and Northrup (**73**) investigated the size of form when the discrimination was from stimuli applied to the volar side of the forearm. The threshold size of these forms was found to be between 12 mm. and 15 mm. across the main dimension. The optimal size had a main dimension of about 18 mm. to 20 mm. In the light of these figures, the forms of the cutaneous stimuli in the present research were equated to a main dimension of 10 mm. in an effort to adopt a subliminal pattern for the cutaneous stimulus.

It may be insisted that these forms would have been below the threshold of discrimination even if the subject had been attending to the stimulus and had been making an effort to discriminate. Furthermore, if with the aid of attention the forms were impotent to effect a differential awareness response, how could a differential response be possible when these stimuli were entirely unnoticed? The same question may be asked in regard to the configuration presented to peripheral vision. The form stimulus which the subject could not identify—was not even sure existed—in peripheral vision did produce a differential effect upon responses. This was also true when the subject was uninformed of the presence of the configuration. There are few psychological or neurological data to aid in solving the problem. Study of the structure of the sense organ and the frequency of receptor endings only complicates the problem. Furthermore, it has been frequently pointed out that reasoning from neurological studies to the type of psychological phenomena under consideration is futile. The psychological phenomena probably have their own neurological correlates, but at present they cannot be described.

Variation III has, in a sense, turned out to be a control series

quite different from that intended for it in the original purpose of the experiment. Since the frequency of correct responses dropped to the level of chance, the series is not only valid for indicating no effect from the cutaneous stimulus, but also in establishing an empirical criterion. It more completely justified the use of the theoretical chance frequency as a valid criterion in evaluating the effects of the other series. If the excess of right choices had been the result of some error in method, it should have had equal manifestation in Variation III. The data also give evidence that no ESP factor was operating to bias the results.

The effect of unnoticed stimuli upon the processes of threshold, or near threshold, value merits further consideration than that given in the introductory section. The stimulus limen is defined for convenience as that value of stimulus intensity which is just sufficient to excite a sensory experience. This definition, however, without explanation is misleading. The limen is a variable and must be thought of as a function dependent upon a large number of interrelating conditions. If a single numerical value is used to designate a limen, it should be understood as only typifying a function, as an average which best represents a series of values obtained by repeated judgments from the subject. Were the limen associated with a magnitude of the stimulus which remained constant, one judgment would be sufficient. The variable character of the threshold requires many measurements from which its variability and central tendency may be computed. If we take a series of constant stimuli of different magnitudes and compare each with a standard stimulus whose value is midway between the extremes of the constant stimuli, it will be found that the distribution of a sufficiently large number of judgments will approximate the Gaussian Curve of Error. The frequency of a sensed difference depends directly upon the magnitude of the difference between the standard and the variable. The frequency of error varies inversely with the difference between the stimuli judged. Theoretically, if there were an infinite number of comparisons, even an infinite separation between standard and variable might at some time allow an error. In a long series, positive and negative errors of comparable magnitudes will occur

equally often. The larger the error the less frequently it will occur; conversely, the smaller the error the more frequently it will occur. If we let y equal error frequency and x equal the magnitude of error, then y will have its greatest frequency at x, or error, equal zero. The errors decrease gradually through plus and minus x. Since x may be thought of as the amount of separation between standard and variable with which a certain error frequency is associated, its theoretical limits cannot be defined with certainty. This being true, plus and minus x immediately become plus and minus infinity.

The symmetrical shape of the curve is evidently the product of a large number of uncontrolled psychophysiological variables. At times the combinations dispose the individual to discriminate in favor of a positive difference, at other times in favor of a negative difference. If the stimulus difference is fairly large, the combinations of psychophysiological variables that operate to inhibit discrimination would occur less often. Errors, therefore, diminish accordingly. These factor-combinations have been described rather picturesquely by Brown and Thompson (11).

> "Let us suppose that a quantity which we desire to measure has really the value of 13½ units, but we are opposed in our efforts to measure it by seven 'Djinns', each of whom has the power of displacing our measurement by one half-unit. Let us further imagine that each of these mischievous imps, in an endeavour to prevent our making any steady measurement, decides that he will add or deduct his half-unit according to the throw, heads or tails, of a coin. Whenever we try to make a measurement, therefore, these invisible seven will assemble and throw each his coin in the air. If all the coins happen to come heads, seven half-units are cunningly added to the 13½, and we obtain a measurement of 17. If all come tails, we get 13½ minus 3½ or 10. If on another occasion five are heads and two are tails, five half-units will be added and two subtracted, giving $13\frac{1}{2} + 5/2 - 2/2 = 15$.
>
> ". . . The 'Djinns' which oppose our efforts to obtain a true value for say the spatial threshold are innumerable. Some are in the fingers of the experimenter, and make him press irregularly on the aesthesiometer points. Others cause noises to happen in the neighborhood to distract the subject's attention. Other 'Djinns' make the instrument hot one day and cold the next, others live in the subject's skin, and quite a lot are engaged in stirring up vivid imaginations in his mind so that he feels all kinds of prickles and tinglings which make his judgments on the position of the points as erratic at times as is the throw of a coin" (11, pp. 28, 29).

To extend the analogy, suppose we give one of the "Djinns" a coin with heads on both sides. His effect upon the measurements thereafter, while slight, will all be in one direction. The

central tendency and the dispersion of the measurements will be slightly biased in favor of the double headed coin. One measurement would not show the effect. The influence of the one double-headed coin would be lost in the total results of all the others. But slight effects, if consistent, are bound to show up in a long series.

The double-headed coin represents the experimental introduction of a minute extra-chance influence. To be applicable to the present experiment we must suppose that the " Djinns " each had a six-faced die. Each face of a die was marked with one of the six geometric forms. At each exposure all the dice were thrown. The subject's choice of form was determined by the form shown on the greatest number of upturned die faces. If all the dice of all these hypothetical " Djinns " had been perfect cubes and each cube had had all forms represented upon it, then there should have been an equal distribution of choices of all forms. There should also have been only chance correspondence between the subject's choice and the form which the experimenter might expose. This was not the case. There were two " loaded dice ". One was introduced by the experimenter, the other by the subject. The fact that the experimenter did expose one of the six forms within the subject's range of vision was, perhaps, similar to giving one of the hypothetical " Djinns " a die with all six faces bearing the same symbols. The effects of such a minor extra-chance influence were manifested only in the long series.

The " altered die " cast by the subject was his " Mental Habit " tendency as described in the section on Statistical Method. In keeping with the present analogy, the " die " of the subject could be considered as being loaded so that certain of the faces would turn up more often than the others. This is another way of saying that he was predisposed to choose some forms more often than others. Narrowing the range of choices introduced an extra-chance influence. Insofar, however, as such an influence was introduced, it narrowed the field for any other extra-chance influence to enter and operate toward right cases. Since the

amount of this effect from the "subject's die" could be measured, it was possible to assign the residual effects to the experimentally introduced extra-chance influence.

The other conditions that served to direct the subject's choice at a given moment are almost wholly unknown. When the subject was asked occasionally to tell why he made such a choice, his usual answer was "That was the first form which came to mind and I named it" or "I'm not sure why I gave that name except that I just wanted to". If the questions were pressed further, they usually seemed absurd to the subject. The observers were not urged to pursue such questions for fear they would get suspicious of the real nature of the experiment. It seems to the writer, however, that this might be a lead to some fruitful research. Subjects trained in introspection might be able to identify the significant factors which at a given moment lead to the choice. The techniques of Ach, Watt, Messer and Külpe (69), as they studied the concomitants to the thought processes, are of special significance here.

The fact, however, that the observer displayed so little insight into the predisposing conditions of his choice indicates that the elements of these conditions are unnoticed. Only the result of the mass impression is given in experience. That some of the items of the mass may be isolated and the extent of their effects indicated quantitatively has been shown by the present study.

According to the data of this experiment it seems evident (1) that the subliminal form in peripheral vision continued to be effective in modifying responses in successive experiments (this was shown by a frequency of correct choices in Experiment III that would occur by chance alone less than once in 100,000 sets of 1908 cases); (2) that the cutaneous pressure-stimulus seemed to operate as a slight, though not significant, distraction; (3) that, under the conditions of Variation III, the forms applied to the skin of the forearm did not increase the frequency of correct responses above that expected by chance; and (4) that the data of Variation IV do not indicate that the simultaneous presentation of these similar subliminal stimuli to two sense modalities pro-

duced any reinforcing effects upon the frequency of correct choices, but were similar to those of Variation II in that the cutaneous stimuli seemed to operate as a slight distraction.

Statistical Methods

Several methods are available for determining the reliability of differences or deviations from the theoretical chance frequency. The formulae most frequently used for determining critical ratios for such data are $\sigma = \sqrt{p\,q\,n}$ or $\sigma = \sqrt{\frac{p\,q}{n}}$. The choice here depends, respectively, upon whether one is determining the standard error of an absolute deviation or the standard error of a proportion. The uses of these formulae and the interpretation of the results of application may be found in any of numerous standard texts on statistics.

The purpose of the present section is to describe some statistical processes and formulae which were furnished the writer by the late Professor J. E. Coover in correspondence about the foregoing problems. One of these processes is concerned with the determination of appropriate critical ratios when an extra-chance factor is involved; the other was developed by Coover for separating out the influence of what he had earlier described as "Mental Habit" (**16**). These two processes or methods will be treated separately.

Coover seemed to consider it inadequate to apply the formula $\sigma = \sqrt{\frac{p\,q}{n}}$ to a proportion as is usually done in finding a critical ratio. Ordinarily, the x of the x/σ ratio, when using the above formula, is the percentage relationship of the deviation to the total number of cases. The x as Coover used it referred more specifically to the influence of the extra-chance factor than merely to the proportionate deviation. The x-formula as Coover wrote it is,

$$x = \frac{R/n - p}{q}$$

The logic of this formula may be illustrated by an hypothetical experiment upon coin tossing. If $p = .5$, and wax on one side

of a coin is associated with 70 right (R) cases, *e.g.* heads, out of 100 flips, then R/n = .70. Chance, however, contributed to R also. Therefore, if x = the influence of the wax, and p is chance, then

$$x + p\,(1 - x) = R/n$$

$$x = \frac{R/n - p}{1 - p}$$

But since $1 - p = q$,

$$x = \frac{R/n - p}{q} *$$

Substituting,

$$x = \frac{.70 - .50}{.50} = .40$$

Therefore, x (the wax) accounts for 40 heads, while p (chance) accounts for 30 heads and we have the obtained results represented by $x + p = 70$. Forty heads represents the theoretical influence of the wax. It remains, however, to be determined how frequently in a long series of similar experiments chance fluctuations themselves could produce as many heads in excess of the theoretical average. The complete formula for the critical ratio demanded by this last problem would read,

$$x/\sigma = \frac{\frac{R/n - p}{q}}{\sqrt{\frac{p\,q}{n}}}$$

The x of this formula, it will be observed, is somewhat larger than the x or the deviation usually used. How much greater the x is than the usual difference, *i.e.*, $R - p$, is dependent upon the probability of R cases.

The second statistical method communicated to the writer by correspondence with Coover is one designed to correct for the effects of what he called " Mental Habit " (**16**, p. 229f). Before describing the method of this correction it is necessary to point out two assumptions which the statistical processes thus far have implied. The first assumption has been that, were there no

* Coover's earlier application of this type of formula to similar data may be found in reference **16**, pp. 206, 208f.

extra-chance influences operating to bias the subject's responses, the "guesses" would present a random distribution. That is, the subject would guess each form equally often in a long series. The second assumption was that, if a slight extra-chance influence is experimentally introduced, the excess of R guesses above chance will be due only to this influence plus possible chance fluctuations. Neither of these assumptions is altogether correct. The predisposition of the subject to favor one type of guess more than another permits a form of constant error. This characteristic of the guessing response seems to be beyond the control of instructions. It is this tendency to favor one type of selection rather than another that Coover has called "Mental Habit."

The tendency is not confined to the guessing response. It appears wherever the individual is required to make a judgment, a selection, or a guess. Coover writes,

> "It has long been known that judgments are modified in such ways as are not creditable to the person delivering them, and thus involuntarily, or in such ways as show systematic or constant biases where no conscious motive can be conceived to operate; but only after general interest in statistical matters had been developed in the sociological and psychological fields did knowledge of the extent of this involuntary control of judgment, and of its nature, become definite. We now know that mental habits pertain to numbers, letters, colors, time and space divisions, and to almost everything about which a judgment can be made at all, and that they are so prevalent that perhaps no considerable number or class of judgements is free from them, whether the judgements are delivered by a reagent in a thought-transference experiment in a psychological laboratory, by a judge of the supreme court in sentencing a convicted prisoner, by a teacher who is estimating the scholastic merit of a student in assigning him a grade-mark in a specific subject, by an astronomer who is estimating the magnitude of a star, by a signal service meteorologist in estimating the temperature or the amount of precipitation, or by a psychologist who is estimating tenths of a vibration on a kymograph time-record" (**16**, p. 230).*

In this monograph, Coover presented curves based upon census returns showing that individuals in giving their age use the round numbers most frequently. This tendency is not to be thought of as associated with intellectual incompetence. Coover showed that judges, who are supposed to be intellectually superior, favor certain typical sentences. One would expect that gradations in the seriousness of crimes committed would present a fairly even distribution; the sentences, however, that are imposed are found

* Cf. Goodfellow (**32**).

to pile up at certain favored lengths of time to be served. Even the astronomer in estimating star magnitudes or the psychologist in estimating tenths of a vibration on a smoked drum record are found to favor certain approximations rather than others.

Although the instructions of the present experiment attempted to control as far as possible this tendency, the data indicate that

RESPONSES

STIMULI	Cir.	Hex.	Sq.	Dia.	Tri.	Cross	Total Stimuli
Cir.	77 fxy	35	46	52	48	58	316
Hex.	60	36 fxy	52	58	44	69	319
Sq.	53	34	56 fxy	57	53	66	319
Dia.	62	32	47	67 fxy	39	72	319
Tri.	58	34	46	51	62 fxy	65	316
Cross	50	40	45	61	40	83 fxy	319
Total Choices	360	211	292	346	286	413	1908

fy

fx

FIG. 3. Frequency of responses associated with each of the subliminal stimuli in Variation I, Experiment III.

the subjects were not free from this type of bias. By a line of mathematical reasoning derived from methods of determining the Coefficient of Mean Square Contingency, Coover has developed a formula to correct for "Mental Habit". In a letter he said that,

"... when the respective stimuli are presented equally often, the effect of 'Mental Habit' cannot be positive in sign, that is, it cannot add to R cases; but it can be negative, in the sense that it limits the field for any other cause than chance to enter and work toward R cases."

To illustrate the Coover method of correcting for "Mental Habit", the data from Experiment III, Variation I, are used. Figure 3 presents these data in their coördinate form with notations appropriate to the formulae.

The general formula for "Mental Habit" is

$$M = \frac{(fx - fxy)(fy - fxy)}{N_1^2} - p$$

where,

M = Mental Habit
fx = No. of presentations of stimulus
fy = No. of guesses of the stimulus
fxy = No. of right guesses of stimulus

Hence,

f − fxy = No. of errors of stimulus
N_1 = Whole number of errors

Applying the formula to the data of the chart we have the following six types of substitutions:

(1) (360 − 77) (316 − 77) = 67637
(2) (211 − 36) (319 − 36) = 49525
(3) (292 − 56) (319 − 56) = 62068
(4) (346 − 67) (319 − 67) = 70308
(5) (286 − 62) (316 − 62) = 56896
(6) (413 − 83) (319 − 83) = 77880
(fx − fxy) (fy − fxy) = 384314

$$M = \frac{384.31+}{2{,}331{,}729(N^2)} - p$$
$$= 0.1648 - .1667$$
$$= -0.0019$$

The minus sign indicates that "Mental Habit" worked against R cases. That is to say, whatever extra-chance influence was operating in the direction of R guesses was inhibited to the extent of −.0019 in terms of the following equation.

The whole equation for determining the *ratio* of subliminal influence, segregated from *M* and chance, is

$$x = \frac{R/n - M - p}{q}$$

Where

x = Ratio of R in excess of *p*
R = Right cases
M = " Mental Habit "
p = probability of R cases
q = probability of W cases

It will be noted that the correction for *M* is applied directly to the ratio formula for *x*, which was illustrated on page 51f. Applying this formula to the data we have by substitution:

$$x = \frac{\frac{381}{1908} - (-.0019) - .1667}{\frac{5}{6}}$$

$$x = .0410$$

This derived value (.0410) is the ratio of the effects of subliminal impression after the influences of chance and " Mental Habit " have been isolated. It remains to be determined whether or not the ratio .0410 is more of a deviation from .1667 than chance fluctuation allows.

When the ratio method just described is used for finding *x*, σ is determined by the formula

$$\sigma = \sqrt{\frac{p\,q}{n}}$$

Substituting the values used in the illustrations thus far,

$$\sigma = \sqrt{\frac{1/6 \cdot 5/6}{1908}}$$

$$\sigma = .0085$$

$$\frac{x}{\sigma} = \frac{.0410}{.0085}$$

$$= 4.80$$

The correction for " Mental Habit " is not applicable unless it can be shown that *x* is present in spite of this inhibiting influ-

ence. It is conceivable that $p = \frac{R}{n}$ in a situation where the subject has given all his guesses in terms of one stimulus. For example, all guesses might have been " Squares ". Had this been true, p would necessarily equal $\frac{R}{n}$ because all stimuli occurred equally often. Any correction for M would make $\frac{R}{n} > p$. This would imply an extra-chance factor which the data at face value do not warrant. The presence of x must, therefore, be established before the " Mental Habit " correction is appropriate.

Summary

The objectives of the foregoing experiments centered primarily about the effects of subliminal stimuli upon choice responses of human subjects. While previous experiments had shown that stimuli of the unnoticed and subliminal categories were effective in modifying responses, no experiment had been organized for demonstrating possible reinforcing effects from two similar subliminal stimuli applied to different sense modalities. The major purpose of the present research was to determine if two objectively similar subliminal stimuli applied simultaneously to the visual and the cutaneous senses would have more influence upon modifying responses than if the subliminal stimuli were presented independently to each of these sense organs. The following six geometric forms were used as the stimulus patterns: circle, hexagon, square, diamond, triangle, and cross. Geometric forms were chosen because they might be presented as objectively comparable stimuli to both sense organs, the eye and the skin.

Three experiments were performed. In the first experiment it was determined, by tachistoscopic exposure of geometric forms to peripheral vision, how small the form must be to become subliminal at seven degrees of eccentricity. The second experiment, like the first, was performed entirely with the tachistoscope. The subject, however, in this procedure was uninformed about the presence of the geometric form in peripheral vision. Atten-

tion was occupied by material in the center of the exposure card. After each exposure, and along with other reports, the observer was asked to choose at random one of the six geometric forms which were shown to him on another card. Three sizes of forms were used. It was possible to determine (a) whether an unnoticed stimulus would influence responses, and (b) whether change in size of form would give a concomitant modification of response.

The third experiment introduced the cutaneous stimulus. Its size was determined on the basis of experiments by Zigler and Northrup (**73**). Four variations or series were run. Variation I presented the form tachistiscopically to peripheral vision. Variation II was precisely the same as I except that a pressure stimulus of 100 grams was applied to the volar side of the forearm simultaneously with the visual stimulus. The areal form of the pressure stimulus remained constant throughout this variation. In Variation III geometric forms were applied to the arm (pressure 100 grams), but no form appeared in peripheral vision. In Variation IV the same forms were presented simultaneously to both peripheral vision and the skin. The subject was kept in ignorance of the peripheral patterns in vision and the geometric nature of the cutaneous stimulus.

Conclusions

Experiment I

1. Forms exposed for a 90 millisecond duration at seven degrees below the fixation point must be larger than 1/4 degree across the main dimension to give the observer any basis for discrimination upon consistently recognized cues.

2. Forms which are even smaller than this give significant, though slight, biases to the frequency of correct discriminations.

Experiment II

1. Unnoticed stimuli seem to operate only under special conditions in modifying responses.

2. The task "in attention" must be disposed of to some extent before the unnoticed stimuli becomes observably effective.

3. Smaller or weaker unnoticed stimuli, when in the form of geometric patterns, apparently have a greater effect than larger or more intense stimuli.

4. There is some evidence of confusion between similar forms in their effectiveness as subliminal stimuli.

Experiment III

1. The subliminal form in peripheral vision continued to be effective in modifying responses. This was shown in a frequency of correct choices that would occur by chance alone less than once in 100,000 sets of 1908 cases.

2. The cutaneous pressure stimulus seemed to operate as a slight, though not significant, distraction.

3. Under the conditions of Variation III, the forms applied to the skin of the forearm did not increase the frequency of correct responses above that expected by chance.

4. The data of Variation IV do not indicate that the simultaneous presentation of these similar subliminal stimuli produced any reinforcing effects upon the frequency of correct choices. The data are similar to those of Variation II in that the cutaneous stimulus seemed to operate as a slight distraction.

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